

Can. Dept. of Energy, Mines & Resources

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Department of Energy, Mines and Resources



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INTRODUCTION

The objective of the Department of Energy, Mines and Resources is to ensure the full and effective use of Canada's energy and mineral resources for the benefit of all Canadians. Its mandate encompasses the development, coordination and implementation of federal policy governing energy and mineral resources and the carrying out of research to obtain the scientific, technical and economic information basic to the making of such policy.

Canada must plan and prepare for enormous demands on its energy and mineral resources both nationally and internationally. It is a resource-based nation, but it does not have an unlimited supply of energy and mineral resources. One of EMR's fundamental and pressing projects is to complete an inventory of Canada's energy sources and a forecast of domestic needs. Another is to formulate meaningful energy policies tailored to Canada's resource situation and to the best interests of the national economy.

EMR must also ensure that the country's needs for mined products are met. It is thus focusing greater effort on policy formulation and programs to increase returns from exports and to improve the socio-economic effects of mineral industry development throughout the nation. In 1971, for instance, the department, in cooperation with the provinces, initiated a program to investigate the mineral potential of the depressed gold-mining region of northern Ontario and Quebec in an effort to improve the socio-economic status of the region.

The department's mission is both challenging and complex. This report is a summary of its major activities in 1971.

ENERGY DEVELOPMENT

The tremendous growth in energy consumption in the world's industrialized nations and the increasing awareness that Canada's energy resources constitute a valuable but exhaustible supply, whose use must be carefully planned and regulated, have given new weight and responsibility to the department's Energy Development Sector. It examines energy in all its forms — coal, oil, gas, uranium, and conventional and nuclear-generated electric power — to ensure that national development policies are related in the most effective and economic way to Canadian needs. As policy considerations must have regard to the total energy picture, the sector studies and assesses individual projects and developments relative to each of the energy sources and in terms of interrelationships with other energy sources. It administers and manages the federal interests in mineral resources offshore from Canada's east and west coasts and in the Hudson Bay region, as well as those federally-owned mineral rights in the provinces that become available for disposition, and it makes policy recommendations on offshore resources.

Uranium Stockpiling Program

A formal agreement was reached with Denison Mines Ltd., the largest Canadian producer of uranium ore, concerning a joint stockpile program to ensure the basic economic security of the Elliot Lake community, where Denison is the major employer. A new Crown corporation, Uranium Canada Limited, was incorporated in 1971, which will have at its disposal \$29.5 million for the purchase of about 6.3 million pounds of uranium oxide from Denison during 1971-74. The stockpile will be owned jointly by the federal government and Denison, at a proportion of 75-25, and be maintained on a contractual

basis by Eldorado Nuclear Ltd. Denison will act as sales agent for the stockpile. Canadian Government policy limiting the proportion of foreign ownership in Canadian uranium production stipulates that owners of companies engaged in duly authorized exploration for uranium on March 2, 1970, and owners of producing companies will be permitted to retain their holdings. However, any sale of such holdings must be to Canadian residents until the total foreign ownership is reduced to 33 per cent. Also, no foreign investor, or group of associated foreign investors, will be allowed to retain more than 10 per cent of ownership of the property.

Uranium-enrichment Plant

The sector continues to study in depth the question of the possibility of an uranium-enrichment plant in Canada. The subject was discussed during the missions led by the Minister to Japan, Australia, and Europe. The mission to Australia served to acquaint departmental officials with the uranium situation in that country and the attitude of the Australian Government and industry on the marketing of Australian uranium. Australians favor the orderly development of their sales.

Northern Oil Development

A Task Force on Northern Oil Development, established in 1968 to advise and make recommendations to the federal government on northern oil development, particularly the impact of pipeline construction in the Yukon and Northwest Territories, and on the economy at large, is emphasizing the potential effect of oil and gas pipelines on the environment and on social conditions. The Task Force is also studying the economics of pipeline

construction and Canadian participation in its financing. If a northern pipeline is built, it will be one of the largest capital investment projects in Canadian history. Estimates of direct investment needed for such a venture run to over 3 billion dollars, in addition to the investment in such services as roads, communications networks and communities in the North.

Oil Production and Marketing

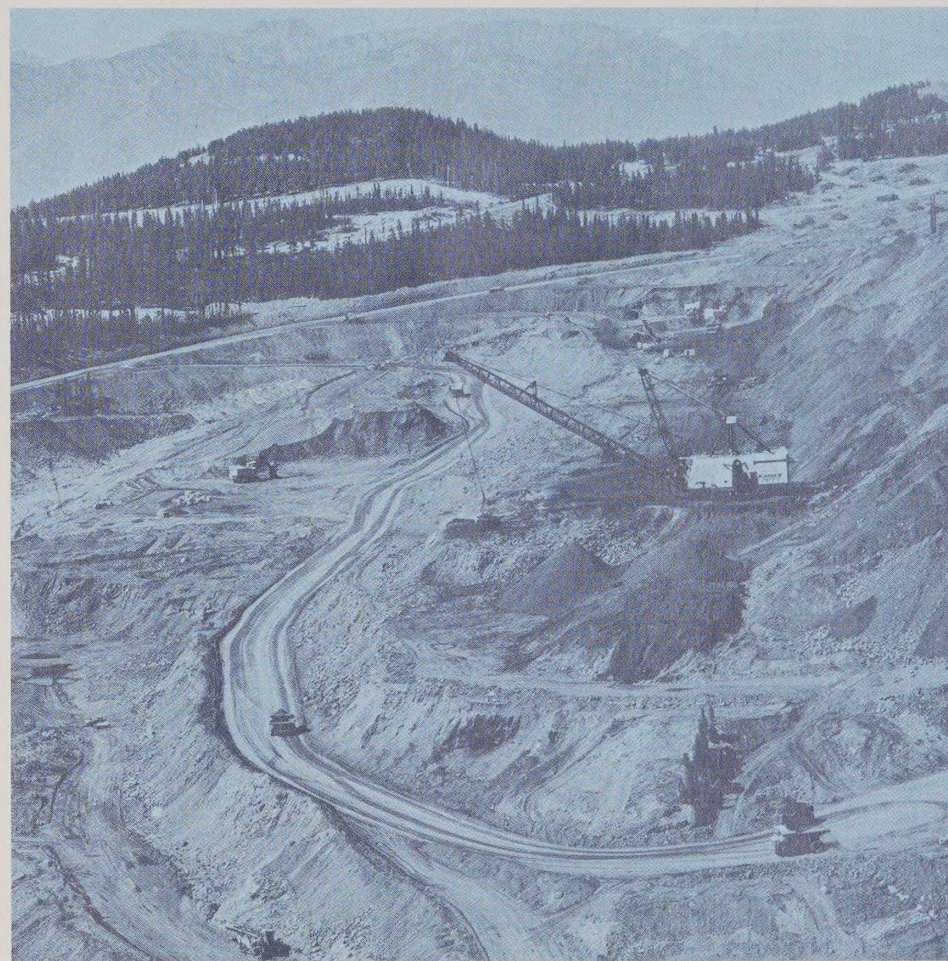
The sector has coordinated an interdepartmental study of oil production and marketing which seeks to ensure a viable market growth both in the United States and in Ontario, where domestic crude is facing strong competition from imported oil. This involves a review of the national oil policy. It also continued its program of resource evaluation and market analysis on a domestic and on an international basis.

Canada/USSR Agreement

On January 27, 1971, Canada signed an agreement with the Soviet Union for cooperation in the industrial application of science and technology. The sector has a leading role in implementing the agreement where oil, natural gas, and electrical energy are concerned. Arrangements were made in 1971 for an interchange of experts to study various aspects of the oil and gas economies in Canada and the Soviet Union.

The Use of Western Coal in Ontario

The results of a detailed transportation study on use of western coal in Ontario showed, at the moment, that it could not compete economically with U.S.



al. Ontario is almost completely dependent on U.S. coal but uncertainty of the long-term availability of this supply has caused concern. The sector is maintaining a close watch on the situation.

Coal Resources in Western Canada

The interdepartmental advisory committee on coal re-assessed the measured coal resources in western Canada. A preliminary estimate showed that these amounted to 9.8 billion tons and, if indicated and inferred resources were added, the total rose to 118.7 billion tons.

The sector continues to maintain close contact with the Cape Breton Development Corporation (DEVCO) on the maritime coal situation. DEVCO has a new Langan mine under construction near Sydney, N.S., and, in cooperation with the department, carried out a detailed study on the modernization of its No. 26 colliery.

Bay of Fundy Tidal Power

The sector maintains interest in the results of studies on the economic feasibility of Bay of Fundy tidal power in the light of current circumstances. It continued its technical advisory role in power projects that would be of major significance to the power systems of the Atlantic provinces.

Upper Yukon Power Market Potential

The sector published a report, *Upper Yukon Power Market Potential*, summarizing a study conducted with other agencies on the market potential

for power that could be developed by diverting a portion of the Upper Yukon River. The combined potential market would not be adequate to support the undertaking and more remote markets would have to be supplied to create a viable project.

The Hydro Quebec Research Institute

The sector was responsible for coordinating the work of several federal departments pertaining to federal assistance to electrical research with particular reference to the Hydro Quebec Research Institute. Canada is lending a total of \$17,500,000 to Hydro Quebec as well as making a grant of \$325,000 per annum for ten years. The Institute will carry out research in the generation, transmission, distribution and use of electrical energy for the ultimate benefit of the Canadian electrical utilities and the supporting electrical manufacturing industry.

Columbia River Treaty

The Assistant Deputy Minister (Energy Development) continued his chairmanship of the International Columbia River Treaty Permanent Engineering Board and the federal chairmanship of the B.C.—Canada Columbia River Advisory Committee. Under the treaty, two Canadian storage projects have been completed and the third and final one, the Mica Dam, is under construction and will be finished in 1973.

Nelson River Power

Expansion of the electrical transmission system connecting Manitoba's Nelson River hydro-electric power sites to the Winnipeg area was announced

in December by the Acting Minister and the Premier of Manitoba. The system will be expanded from a capacity of 1,000 megawatts at a cost of \$170 million to be completed by 1972 to approximately 1,350 megawatts at an additional cost of \$30 million to be completed by 1974.

Fuel-fired Electric Generating Plants

The sector sponsored, with the Department of the Environment, a consultant's study on the cooling water requirements of fuel-fired electric generating plants, including possible environmental effects from the discharge of heated water to natural water bodies. The broad conclusions seem to be that, although local restrictions to heat discharged to the environment may influence the selection of specific sites for thermal power plants, the total magnitude of heat discharge to the year 2000 does not represent a serious problem. Consultation is taking place with electric utilities industries to determine the most appropriate areas for further study.

Offshore Mineral Resource Management

Engineers of the Resource Management and Conservation Branch carried out on-site inspections of offshore mineral resource operations, particularly offshore drilling, as part of its task of setting and enforcing standards for safe and pollution-free operations. Four large drilling vessels were in operation off Canada's east coast in 1971 and a fifth vessel is under construction at Halifax. Nineteen exploratory wells were drilled resulting in one discovery, a significant oil and condensate gas find on Sable Island.

Preliminary investigations by government and industry indicate that much of Canada's submerged continental margin which has an estimated area of



almost two million square miles, or about half the total land area of Canada, is prospective for oil and gas, with indications of other minerals as well. Over a million square miles of the offshore are under exploratory permit to numerous oil companies.

The branch's regional office-laboratory at Dartmouth, N.S., was expanded to accommodate a team of subsurface geologists and technicians from the Geological Survey of Canada who are carrying out extensive analyses of rocks from offshore wells.

MINERAL DEVELOPMENT

The Mineral Resources Branch is concerned with minerals from a resource management viewpoint and, in issues of national concern, it recommends on policy and short- and long-range marketing options. It specializes in inter-disciplinary research in resource and engineering economics and collects information on mineral resources and mineral-based industries in Canada and in other countries of the world. It interprets analyses of a wide spectrum of government-industry activities in relation to economic, social and technological change, and monitors trends. The resultant data and conclusions are made known to government through reports and to the public through branch publications, and serve as a basis for policy decisions by federal and provincial departments and agencies, and by industry.

Development of National Mineral Policy Alternatives

There is a growing public awareness of the potential contribution of mineral resources to the well-being of Canadians. Expanding foreign and domestic

demands on these finite resources are causing concern. Such factors have helped demonstrate a need for a national mineral policy. The branch is contributing to the formulation of such a policy through a broad range of studies and forecasts. Immediate projects include comparative studies on legislation and regulations affecting mineral-resource use in Canada.

Taxation and Foreign Ownership

The branch undertook a comprehensive review of the effects of alternative taxation policies on the mineral industry, in connection with the government's tax reform.

At the request of the Government Task Force on Foreign Ownership, the branch is participating in the study on the resource-based industries. It is also studying legislation relating to foreign ownership and reviewing foreign investment policies in several countries comparable to Canada.

Environmental Quality

The effects of mining and related activities on the environment have created a need for harmonizing economic and social objectives. The branch is, therefore, participating in the preparation of the Canadian Council of Resource Ministers Conference on Outdoor Recreation in 1973, and of the United Nations Conference on the Environment to be held in Stockholm in 1972. It is also analyzing the environmental implications of coal mining in western Canada, taking into account mining activities, geology, and economics.

Social Development

Although the opening of a mine or mines usually leads to the growth of new communities and prosperity in remote areas of the country, mine closures have

a severe reverse effect. The branch is allocating additional resources to search for ways of easing the social dislocations resulting from such events.

The branch is responsible for administering the Emergency Gold Mining Assistance Act, which is designed to minimize the social and economic hardships on a number of communities dependent on gold mining, which is rapidly declining. The Mineral Resources Branch, in collaboration with the Geological Survey of Canada, held, in Ottawa in May 1971, a 'Gold Workshop' involving officials from the Ontario and Quebec governments and the mining industry to examine the feasibility of launching a special scientific and technical program to provide a base for diversified mineral development in the traditionally gold-mining region of Timmins-Val d'Or of northern Ontario and Quebec.

Regional Development and Mineral-based Activities

Mineral industries may help significantly to reduce regional economic disparities by creating more employment and higher incomes. An important aspect of such development is the diversification of a regional economic base through development and further processing activities. The Mineral Resources Branch cooperates with several federal and provincial agencies in this field. Projects include: an analysis of opportunities for the further processing of Canadian minerals, with forecasts for the next five years; a study in cooperation with the Ministry of Transport, of the feasibility of extending transportation networks in northern British Columbia, the Yukon and the Northwest Territories, and resource planning and agreements with various provinces to encourage mineral development. An example of the latter is a program for New Brunswick, in cooperation with the province and the Department of Regional Economic Expansion, which has resulted, to date, in the discovery of potash and salt deposits.

Foreign Aid and Research Grants

The branch contributes to the Canadian International Development Agency's program of foreign aid by arranging for the training of foreign students in the minerals field. It provides advice and evaluations on questions relating to proposals for capital projects in other countries and in the selection of experts for foreign aid projects abroad. For example, branch members are in India and Burma carrying out an assessment of the economic potential of foreign deposits.

Mineral Industry Analyses

The branch's economic research and analyses provide the basis for advice and recommendations on resource management and the performance of the mineral industry. These concern such factors as mineral management, the adequacy of resources supplies, exploration, mining, smelting, refining, uses, prices, trade, tariffs, foreign developments and other aspects that may vary among mineral commodities. Forecasts play a vital role in relation to policy formulation on issues of national concern. The activities in this area frequently involve the branch in international meetings. For example, the branch represents the department on the OECD (Organization for Economic Cooperation and Development) International Lead/Zinc Study Group and the International Tin Agreement Meetings.

SCIENCE AND TECHNOLOGY

The Science and Technology Sector carries out a broad range of scientific research pertaining to the earth sciences: geodesy, geology, geophysics, mineralogy, metallurgy and geography. It is responsible for acquiring a

knowledge of the physical characteristics of Canada's land masses, its energy and mineral resource potential, and the basic data essential for engineering and resource development purposes. Through its surveys, maps and reports, it furnishes the scientific data about the earth's crust necessary for the efficient development, use and conservation of the country's natural resources.

MAPPING

Accurate maps and aerial photographs are basic tools for resource development and are essential for industrial, scientific, educational, the tourist industry and other enterprises. Demand for maps, photographs and survey data continues to rise. During 1971, over 4,000,000 maps and almost 1,000,000 air photos were sold.

The Surveys and Mapping Branch placed 400 men in the field across Canada in 1971 to carry out a \$1.8 million program of surveying and mapping.

Map Coverage

The branch has just completed one of the world's greatest surveying and mapping feats — the mapping of all Canada at a scale of 1:250,000, or four miles to the inch. This map series comprises 918 sheets and covers an area of over 3.5 million square miles. It took 44 years to complete.

Meanwhile the branch continues to map Canada at the scale of 1:50,000, or approximately three quarters of a mile to the inch. It has already completed about one third of the country at this scale. This coverage, which is essential for resource development and engineering projects, exists for the Maritime Provinces, southern Ontario and Quebec, the Prairies, southern British

Columbia and many areas of northern Canada. In the Northwest Territories, the branch has completed the mapping of 102 (of a total of 190) topographical maps of the Mackenzie River Corridor which has a total area of 25,000 square miles. This mapping will enable planners to locate possible routes and ancillary services for oil and gas transmission.

Control Surveys

Accurate surveys are essential to the production of accurate maps but they serve many other engineering projects. Precise levelling (i.e., determining the exact height of points above sea level) is vital to engineering projects, such as hydro-electric power development, irrigation, and domestic and industrial water supply. The branch has completed a six-year project consisting of a resurvey of a level line across Canada from Halifax to Vancouver. It is also running a series of very precise level lines in the vicinity of the Bennet Dam to ascertain whether the impounding of this vast artificial lake is causing any detectable movement in the earth's crust.

The branch extended the network of control for mapping across the northern half of Yukon connecting with the existing control in the Yukon-Alaska boundary. The branch continues to use aerodist (an airborne electronic measuring system) for such work in areas difficult of access where ground surveys would be extremely expensive and hazardous. Aerodist allows fast accurate measurements of distances up to 200 miles.

Two aerodist programs were carried out in 1971. The first was based at Thompson, Manitoba, and established primary and mapping control over a 35,000 square-mile area for use in oil, mining and legal surveys. The second established control in Saskatchewan over an area bounded by the Alberta, Northwest Territories and Manitoba boundaries and the 57th



parallel. This control will be used for positioning the legal boundaries of mining claims and for other resource surveys.

Geodesy via Satellite

Canadian surveyors and map-makers will soon be able to rely on the most precise positioning data that space-age technology can provide, thanks to a joint Canada/U.S. satellite triangulation survey. The survey, which started in 1964, entered its final stage in March 1971 with the movement of observing stations to Frobisher Bay on Baffin Island and to St. John's, Newfoundland. It will result in the most accurate geodetic grid ever achieved in Canada and will serve as a basis for correcting and densifying the existing survey framework. A geodetic grid is the starting point for all other types of surveys: topographic, hydrographic, municipal, legal and engineering.

Assistance to Developing Countries

The Surveys and Mapping Branch continues to provide technical advice and engineering support to the Canadian International Development Agency in topographical mapping projects in Tanzania, Nigeria, Trinidad, Guyana and Jamaica. It also provides training in surveying and mapping techniques to students from developing countries attending Canadian technological institutes and universities. One such course in 1971, a 12-week seminar, was attended by students from Africa and Commonwealth countries of the Caribbean.

Publications

The branch published two gazetteers during 1971. These were the Gazetteers of Yukon Territory and the Northwest Territories. Together they list more than 11,000 places and give the precise latitudes and longitudes of each.

GEOLOGY AND GEOPHYSICS

The Geological Survey of Canada in 1971 placed 125 parties in the field to carry out a \$3.4 million program of mapping and investigation of Canada's geology.

One of the field parties in August reported the finding of copper occurrences of a new type in the Smithers map-area of British Columbia. At least 20 mineralized occurrences were found.

The Geological Framework of Canada

The Survey initiated a program of upgrading earlier reconnaissance geological maps to determine the mineral potential of the North. In 1971 it undertook studies in the Yellowknife and Hearne Lake areas of the District of Mackenzie, in parts of Labrador and in the district of Keewatin.

EMR geologists are continuing the initial geological reconnaissance of the Cordilleran Region in western Canada by aircraft-supported operations. In Operation Stewart in 1970, they completed 20,000 square miles in central Yukon. They are now mapping the southern part of the rugged Coast Mountains and have made a start on the mapping of one of the last unmapped areas of British Columbia — the Fort Grahame area, including part of the Omineca Mountains, in the north-central part of the province.

The Survey has mapped almost all of the Arctic Islands at least on a reconnaissance scale. Highlights of its current work, based on this earlier reconnaissance, are Operation Grant Land, a study of the mountainous belt extending through the northern part of the archipelago and into northern Greenland; Operation Grinnell, a study of a key area in a potentially

favorable oil and gas region in southwestern Ellesmere Island, and Operation Foxe Basin, a preliminary evaluation of the hydrocarbon potential of the basin.

Airborne Geophysics

In 1971, a total of 125,000 square miles of territory was covered by federal-provincial aeromagnetic surveys in Quebec, Labrador, central Baffin Island and in the District of Keewatin. These surveys have played a vital part in opening up Canada's hinterland to mineral exploration. Since 1948, a total of 1,843,000 square miles has been mapped. The surveys are produced by commercial air survey companies flying to the specifications of the Geological Survey under its supervision. The cost is shared jointly by the federal and provincial governments. The project is scheduled for completion in 1974.

The high-sensitivity airborne gamma-ray spectrometer system, developed by the Survey, demonstrated its effectiveness, for the third season in a row, for identifying potential uranium deposits and geological phenomena of worldwide scientific interest and importance. In 1971 it was used in the Yellowknife area and in Yukon. The system has shown that the Canadian Shield contains not only regional differences in radioactive element content but also major zones tens of miles wide and up to hundreds of miles long where these elements are measurably concentrated. It appears that most of the known uranium occurrences of the Shield occur within these zones, and there is reason to believe that they may also be related to the concentration of other types of mineralization.

Oil and Gas Potential

The GSC is carrying out a multidisciplinary study of Canada's sedimentary basins on the mainland and in offshore areas to assist industry in the location of



oil and gas. In 1970 it set investigations under way in Yukon and Northwest Territories. In 1971 it engaged with industry in a cooperative submarine geological survey of Hudson Bay using a three-man submersible that not only permits observation under water but also sampling and drilling of the bedrock. The Survey is meeting the needs of offshore geology by the establishment of a Marine Geology Unit in Vancouver in 1970 and of an Eastern Petroleum Geology Unit in Halifax in 1971.

The GSC's Institute of Sedimentary and Petroleum Geology in Calgary has initiated a program in organic geochemistry designed to assist in the early evaluation of the potential of relatively unknown areas. Fine-grained rocks from wells and outcrops show traces of hydrocarbon gases which give an indication of the type and amount of petroleum that may be found before any actual discoveries are made.

Mineral Potential and Probability

Recent work of the Survey has been directed to the development of comprehensive geological concepts on major economic metals in Canada as a basis for the selection of favorable areas for prospecting. Such concepts are applied to the estimation and forecast of mineral resources and in defining new areas of mineral potential. A metallogenic map for Canada at a scale of 1:5,000,000 is nearing completion and will provide orientation and general definition of regions with mineral resources. The Survey is also constructing mineral potential maps for different metallic minerals likely to occur in specific areas.

Terrain Surveys

The Survey has expanded and accelerated its terrain survey activities in the Mackenzie region to provide an inventory of terrain conditions within



the Mackenzie River Corridor. These surveys provide information on the expected performance of terrain under the impact of pipeline and related petroleum developments.

The disaster at St. Jean Vianney, Quebec, and the landslide at Casselman, Ontario, are striking demonstrations of the need for geotechnical information on the behavior of terrain materials. The assistance of scientists from the Geological Survey was immediately made available at the sites to learn lessons for the future and to determine the cause of such unfortunate events.

MINING, METALLURGY AND FUELS

Analysis of Ore

The Mines Branch developed a unit that gives an instant readout of the content of slurries, the ore-water mixture used in ore-dressing plants for transporting and separating ores. Precise knowledge of the elements present in a slurry at any given moment is of great value in controlling the process. Branch specialists made use of the fact that various slurry components emit characteristic X-rays when bombarded with radiations from radioactive isotopes. In the unit they used cadmium-109 as the radioactive source for determining iron content in the slurry. The unit can be installed directly in the processing plant. It is expected that, because of its compactness and low cost, it will find many uses in process control.

Moulds for Precision Castings

A process was developed that has greatly speeded up the preparation of moulds for precision castings made of disposable materials, such as wax. Current

industrial practice is to dip the disposable pattern repeatedly into a slurry, after which a coarse aggregate is applied. The whole process, including drying between dips, may take up to 40 hours. Foundry specialists discovered that, by applying an electrical charge, they could reduce the time needed to build up the layers to a few minutes. Branch progress in this experiment indicates that a commercial process can probably be developed.

Pipeline Investigations

The Mines Branch is carrying out investigations of pipe to ensure the structural integrity of oil and gas pipelines constructed in the Canadian North to minimize the risk of pollution and to maintain operational efficiency. The objective is, in the short term, to assess available line pipe of Canadian and foreign manufacture and, in the long term, to develop improved, higher strength line pipe.

Cape Breton Strontium

The discovery and exploitation of large deposits of strontium sulphate on Cape Breton Island prompted branch scientists to look into a better method of extracting and using this metal and thereby assist an emerging industry and the economy of a region in great need of such diversification. As a result, they developed a new concentration process, using flotation. They also studied various parameters controlling the fabrication of strontium ferrites to determine optimum conditions of manufacture. Their results have been used in Canadian industry. Strontium ferrites are the best of the 'hard' or permanent magnet ferrites used in the manufacture of television sets, telephone head pieces, computers and fractional-horsepower electric motors.

Safeguarding Mine Atmospheres

The branch is carrying out research on more efficient and safer mining machinery. Diesel engines are used widely in mining, both above and below ground. They not only emit great quantities of exhaust gases that may be harmful to health, but they may also create hazards in explosive mine atmospheres. The department is therefore constructing a plant for the testing of diesel engines with ratings of up to 400 brake horsepower. The branch will seek ways of avoiding, or reducing, the harmful effects of gas emission and of providing safeguards against the ignition of explosive atmospheres. Research in this field will become increasingly important as coal mining in western Canada moves underground to secure the great quantities of coal required for the burgeoning exports to Japan.

Oil-slick Detection

The branch has made encouraging progress in developing sensitive methods of 'fingerprinting' oil. Much concern has been aroused lately by the accidental or sometimes deliberate spilling of oil by ships navigating near Canada's coasts. Precise identification of the oil makes it possible to trace its source. The principle underlying the fingerprinting method is an analysis of the sulphur compounds that are present in varying degrees in all types of oil. The process also has promising application in improving refining procedures for heavy oils, such as the vast tar sands of northern Alberta.

Transportation of Coal by Pipeline

The Mines Branch is working cooperatively with a major industrial group in the investigation of both the pipeline transportation of coking coal and the



reconstitution of coal so transported. Although coal has been moved by pipeline in the United States for some time, this is still a somewhat novel method of transporting solids, and many aspects of it remain in the experimental stage. This is particularly true of coking coal. The standard method of moving coal by pipeline is to crush the coal into fine particles and to flush these along suspended in water. The problem arises when coal thus crushed and wetted has to be dried and reconstituted into sizes suitable for processing into coke. Requirements for such coal are much more rigid than for coal used in combustion. The project is of special interest to British Columbia coal mines which must find an efficient and economic means of transporting their output to the Pacific coast.

The department is giving favorable consideration to a formal request from the coal industry in western Canada for the provision of additional and adequate coal-testing facilities in that area.

Leaching of Ores

The branch has been studying the leaching of uranium from coarse ore utilizing bacterially-active solutions with the objective of developing a system of static leaching in mine stopes to minimize mining and leach plant costs. Pilot plant tests on minus 8-inch Elliot Lake area ore have indicated that an extraction of 85 per cent of the uranium may be obtained over a period of two years. More recently a cooperative study was carried out jointly with a Canadian uranium mining company, under actual mine conditions, and parallel results were obtained over a 30-week period. This investigation was terminated by suspension of mining operations.

Branch laboratory investigations of static leaching included a bench-scale

study of the mechanism of leaching copper and nickel minerals and ores with acid ferric sulphate media. In view of the very encouraging results obtained in the static leaching of the minus 8-inch uranium ore, plans are now being made to conduct similar large-scale studies on copper, nickel and lead-zinc ores.

In another project, Mines Branch personnel are developing methods applicable to the hydrometallurgical treatment of complex sulphide copper, nickel and cobalt ores. There are a number of deposits of these ores across Canada that are too small to justify the expense of a smelter and where it is also impracticable to concentrate the ore sufficiently by physical means to ship it to an existing smelter.

Mines Branch specialists have concluded that a sulphuric-acid leach with a moderate oxygen over-pressure, followed by cementation or solvent extraction treatment of the resulting metal-bearing leach solution, is a promising route to the realization of an economically viable flowsheet for treating this type of sulphide deposit. In addition to this route being attractive from the metal recovery point of view, it has the additional advantage of converting much of the sulphide sulphur to elemental sulphur rather than water-polluting sulphate.

Mining Research

Of great interest to the mining industry is an experiment carried out by the branch, in collaboration with a private company, in the artificial support of open-pit slopes. Most mines in Canada are of the open-pit rather than the underground type, and branch experts have estimated that, if it should prove feasible to cut slopes to steeper angles, a single mine could save tens of millions of dollars per year through reduction in the excavation of waste rock.

To prevent dangerous rock falls from a steeper slope, a wire mesh was laid over the slope and anchored securely at top and bottom. The entire installation was put together at the site. The experiment carried out along these lines demonstrated the feasibility of this method, and it is now up to the mining industry to develop it further for full-scale practical application.

EARTH PHYSICS

Aeromagnetic Survey

Four scientists carried out an airborne aeromagnetic survey covering Canada's Arctic Islands and about a third of the Arctic Ocean in just six weeks at the end of 1970. Flying a total of 50,000 miles in a DC-6B aircraft, the team measured the direction and intensity of the earth's magnetic field along 22 parallel flight-lines, spaced 40 miles apart. The survey provided vital information for navigation on over-the-pole airline routes and mapped the large-scale patterns of magnetic anomalies associated with ocean ridges. Some of the ridges are active, where the ocean floor is splitting and spreading apart; most have been inactive for years, but still retain their characteristic magnetic anomaly patterns. By interpreting these anomalies, the scientists hope to learn more about the history of the Arctic Ocean and to understand the processes that have formed deposits of oil and gas and of other potential mineral wealth in Canada's Arctic.

Recent paleomagnetic investigations have indicated that, 200 million years ago, Vancouver Island was not part of the North American continent, but was thousands of miles out in the Pacific.

Magnetic Charts

Five magnetic charts were published at a scale of one in ten million, showing the strength and direction of the earth's magnetic field and its annual change over Canada and the neighboring ocean regions. The charts were drawn by computer, according to a mathematical model derived from an analysis of over 55,000 observations obtained since 1952, mainly in airborne surveys. The same mathematical model can be used to provide magnetic information for thousands of maps published by the department, including aeronautical and marine navigation charts.

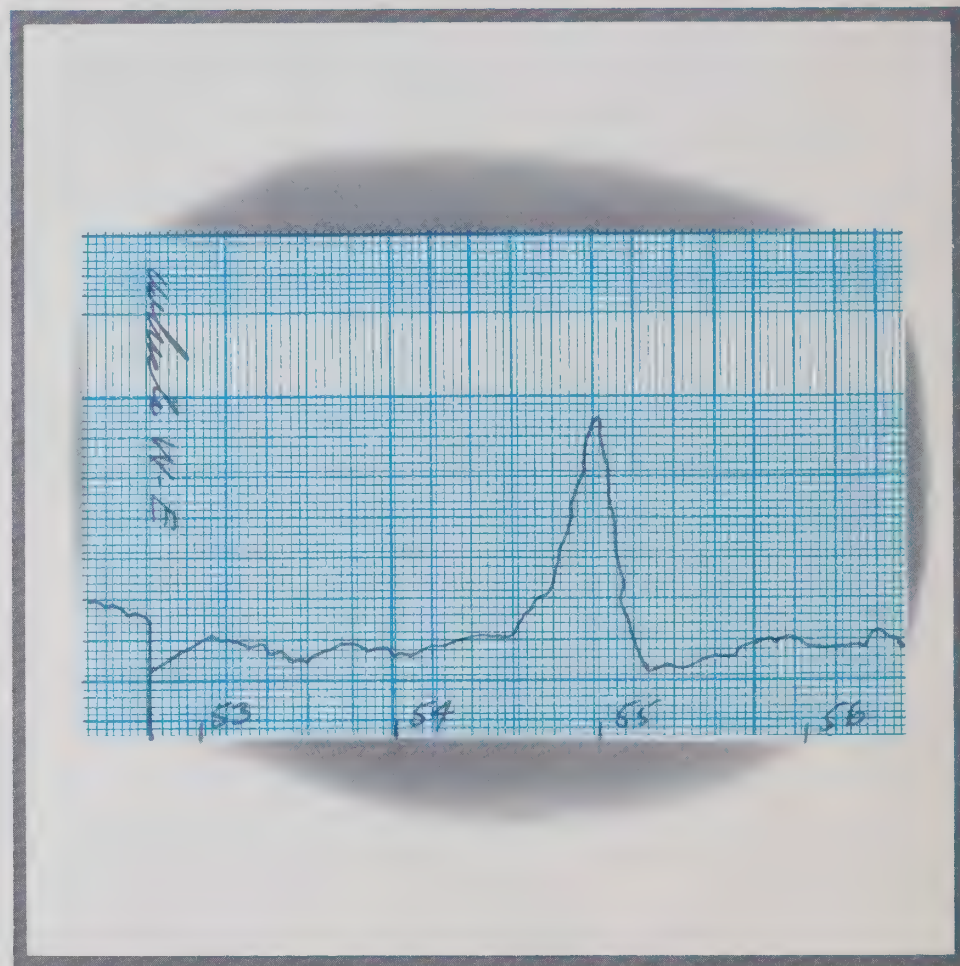
The North Magnetic Pole continues to move northward at a rate of six miles per year. It is now in the northern part of Bathurst Island.

Magnetic Observatories

Six of the ten Canadian magnetic observatories are now equipped with a magnetometer system, developed in the Ottawa geomagnetic laboratory, which records on digital magnetic tape in a form that can be read directly by high-speed computers. The new system not only increases accuracy and eliminates many manual operations and calculations, but also permits sophisticated analyses of magnetic variations that were previously impractical. It also makes possible unattended magnetic observatories requiring inspection visits only once a month instead of the daily attention demanded by the classical instruments. The new magnetic observatory at Cambridge Bay, NWT, has been designed for unattended operation, with considerable savings in construction and operating costs.

Seismic Stations

Procedures on Canada's extensive seismic network have been developed permitting the daily receipt of automated reports of seismic readings from the



stations. All the Canadian standard seismic stations supply information for the determination of earthquakes throughout the world in cooperation with the National Oceanic and Atmospheric Administration of the U.S.A.

Earthquakes

The branch continued the major extension of the strong-motion network for earthquake engineering in western Canada, one of the most important seismic areas in the country. The cities of Vancouver and Victoria, in particular, have a high seismic risk. The region is rapidly developing economically with high-rise construction, new port facilities and projected underwater tunnels. Since it initiated the program in 1961, the branch has installed 14 accelerographs and 48 special devices, called seismoscopes, along the coast of British Columbia in buildings on varied geological and local soil formations. In this way, the ground motion following large earthquakes can be measured and its variations with different soil types determined. Strong-motion seismic records are used by engineers to determine the structural response of proposed designs to earthquake motions and to combine safety and economy in the development of these regions. The maximum acceleration recorded to date is nearly 10 per cent of the force of gravity. The material obtained to date shows the effectiveness of associating seismoscopes with the accelerometers and demonstrates the effects of soils. For example, the 1969 earthquake produced ground accelerations at the bus depot in downtown Victoria more than twice as large as those measured by equipment installed at the University of Victoria.

Gravity Survey of Canada

The regional gravity survey of Canada was extended in 1971 over Banks Island and a large portion of the Beaufort Sea. The information gathered is used

to identify areas underlain by sedimentary basins which is, of course, of vital interest to the petroleum exploration industry. A second large-scale gravity survey was completed in the District of Keewatin and a large part of the District of Mackenzie in the Northwest Territories. The area surveyed included King William and Southampton Islands and the southern part of the Boothia Peninsula.

International Gravity Standardization Network

During the past few years, branch scientists have made a significant contribution to a Special Study Group of the International Association of Geodesy responsible for establishing the International Gravity Standardization Network 1971 (IGSN71). The final adjustment, involving 2,000 gravity stations around the world, was made in Ottawa in 1971 using the branch's computing system. This new gravity reference standard was adopted in principle at the Moscow meeting of the International Union of Geodesy and Geophysics held in August 1971.

Gravity Map of the Sudbury Area

The branch has published a Bouguer gravity anomaly map of the Sudbury mining area which summarizes measurements at some 2,300 locations occupied within the last 25 years. To determine the deep structure of the famous Sudbury basin, branch scientists made a detailed analysis of the gravity field in three dimensions, using computer plots extensively. The results show that, although many local gravity anomalies in the area show simple correlation with geological features, the Sudbury structure is complex in form and is probably underlain at depth by a large body of basic rocks.

Additional evidence was also obtained from country rocks, supporting a

meteoritic origin for the basin. An impact origin for Lake Wanapitei, 25 miles northeast of Sudbury, was also determined by gravity and rock type. Coesite, a high-pressure form of quartz occurring naturally only in meteorite craters, and possibly some meteorites, has been identified by X-ray techniques in fractured rock of Lake Wanapitei. This is the first incontrovertible find in a Canadian crater.

THE POLAR CONTINENTAL SHELF PROJECT

The department, through its Polar Continental Shelf Project, continued its investigation of the lands and waters lying to the north of the Canadian mainland carrying out studies in all the major geosciences, plus marine and terrestrial surveying. Field activities were coordinated from Tuktoyaktuk and Resolute. About half of the investigations were focused on the Mackenzie Delta-Beaufort Sea area. In addition, a number of federal government departments and agencies and several Canadian and foreign universities made use of the Project's field facilities. Many studies were cooperative or integrated with several scientific disciplines. Prominent among these was a focus on the understanding of the Arctic physical and biological environment and the possible consequences of the activities connected with resource development.

The largest single program in the activities of the Polar Continental Shelf Project is the Arctic Ice Dynamics Joint Experiment (AIDJEX), a joint Canada/United States study (to which Russia has contributed scientific consultation and theoretical analysis) of the ocean currents. The experiment, which was started in 1970, involves about 20 government agencies and universities. The 1971 field work of AIDJEX included a camp of 60 scientists and technicians

on the ice of the Arctic Ocean. The information from this experiment, which is scheduled for completion in 1975, will aid in the prediction of ice pressures and movement for shipping, the design of arctic ships, submarines and terminal facilities, and the understanding and forecasting of arctic weather and climatic changes.

REMOTE SENSING

Canada and the United States agreed in 1971 to a joint program for use of satellites and aircraft in surveys of the natural environment. Objective of the program is the advancement of remote sensing technology for the monitoring of air, water, land, forest and crop conditions, and the mapping of ice movements and ocean currents in Canadian and American waters. The program will also have applications in geology, hydrology, education and soil studies. Under the agreement, the department will receive data directly from NASA's Earth Resources Technology Satellite (ERTS) scheduled for launching in May 1972. The Canadian ground readout station will be located in Prince Albert, Saskatchewan, and a data-handling centre will be set up in Ottawa, Ontario. Canadian and the United States test areas will be designated for "ground truths" studies and aircraft data relating to these areas will be acquired and exchanged as mutually agreed. ERTS data obtained by NASA and EMR will be made available as soon as practicable to the international community.

The national program on remote sensing is to be managed by a new agency known as the Canada Centre for Remote Sensing. The department's Surveys and Mapping Branch will manage the reproduction and distribution of the data; the Canadian Forces will carry out the airborne surveys, and the Department of Communications will manage the reception of the data at the Prince Albert Satellite Station.

THE ATLANTIC GEOSCIENCE CENTRE

The Nova Scotian Shelf

First analysis of results of a joint geology and geophysics cruise on CSS *Hudson* in the Bay of Fundy and eastern Gulf of Maine indicates that the geological structure of southwest mainland Nova Scotia changes direction on the Continental Shelf from southwest to south, an important clue for the geological history of the continental margin.

Environmental Geology

Scientists at the Centre have established that the presence of humic compounds in bottom sediments helps to dissolve large amounts of metals from their insoluble salts (one gram of humic acid can release up to 0.7 gram of metals).

They also found that mercury in rivers and estuaries on Canada's east coast is concentrated by suspended particles to levels 20 times that found in bottom sediments and is carried downstream in huge quantities (kilograms per day in the Lahave estuary).

On Crichton Island, they observed that natural processes, mainly wave action, cleaned oil-polluted sandy beaches in a matter of months, whereas longer periods of erosion are needed to remove the last stain off bouldery and rocky shores.

Formation of Baffin Bay

Geophysicists at the Centre carried out gravity, seismic reflection and refraction and magnetics surveys aboard CSS *Hudson* in Baffin Bay. In



conjunction with measurements in the Labrador Sea, they established that the formation of Baffin Bay was the result of sea-floor spreading (continental drift) between the Canadian Arctic and Greenland.

Sea-floor Spreading

The Centre participated in the cruise aboard NOAA ship *Surveyor* in the northeast Pacific. This cruise formed part of the US National Ocean Survey Program, associated with the International Decade of Ocean Exploration. The cruise provided information on the pattern of sea-floor spreading west of Canada.

Resources Survey

In cooperation with the hydrographic section (AOL), the Centre is carrying out a systematic program of detailed surveying involving gravity, bathymetry and magnetics over the continental border land. In 1971 the survey covered part of the Grand Banks and Flemish Cap.

